ANALYSIS OF MARTIAN PYROXENE COMPOSITIONS IN SYRTIS MAJOR: FULL MGM APPLICATION TO OMEGA.
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Spectra from the OMEGA visible-infrared spectrometer [1] of the Syrtis Major region of Mars are analyzed for pyroxene composition and the relationships to local geologic units. Individual spectra were analyzed using the Modified Gaussian Model (MGM) [2]. Final MGM fits indicate the presence of two pyroxenes in Syrtis Major, in agreement with previous studies [3, 4]. The results indicate that the old cratered terrains are low-calcium pyroxene rich while the overlying volcanic province is high-calcium pyroxene rich. Olivine is likely present in some regions.

Dataset: The OMEGA spectrometer onboard Mars Express operates with a 1.2 mrad IFOV and 352 spectral channels between 0.35 and 5.09 µm [1]. The spatial resolution varies from 300 meters/pixel at pericenter to 4.8 km/pixel at an altitude of 4000 km. After its first year of operation, the instrument has covered more than 50% of the entire planet. The spectra are corrected from the atmospheric contribution using the method described in [5].

Pyroxenes and the MGM: Pyroxenes exhibit diagnostic 1 and 2 µm absorption bands in the near-infrared wavelength range resulting from crystal field transitions of iron in octahedral coordination [6]. The positions of these absorptions vary systematically as a function of composition and crystal structure [6,7]. The presence of calcium, iron, and magnesium in the M1 and M2 crystallographic sites affects the locations and shape of these distinct absorptions [6]. Most significant to this study is that increasing calcium content in pyroxene shifts the 1 and 2 µm absorption features to longer wavelengths [7]. The band centers of low-calcium pyroxenes (e.g. orthopyroxenes) occur at about 0.9 and 1.8 µm and the band centers of high-calcium pyroxenes (e.g. clinopyroxenes) at 1.05 and 2.3 µm [7].

It is possible to estimate pyroxene compositions of reflectance spectra using the Modified Gaussian Model (MGM) [2]. This method deconvolves individual absorptions of mafic minerals, particularly pyroxenes, by fitting a series of modified Gaussian absorptions superimposed on a baseline continuum [2].

[2] demonstrated that the MGM appropriately fits a single absorption at 1 µm and single absorption at 2 µm for pure orthopyroxene and pure clinopyroxne. For spectra of pyroxene mixtures, the MGM uses a low-calcium (LCP) and high-calcium (HCP) absorption component for each of the 1 and 2 µm regions [8]. The relative strengths of the LCP and HCP components both in the 1 and 2 µm wavelength ranges are indicative of their relative abundances [8].

The MGM has been used in previous studies of Martian pyroxene compositions using laboratory data of SNC meteorites [9] and orbiter data for Mars (e.g. ISM [3] and OMEGA [4]). The analysis of [4] includes the full OMEGA dataset but fits the 2 µm band and allows only the strengths to vary. Our study compliments prior analyses of OMEGA data [4] by incorporating the 1 and 2 µm absorption band features and by allowing complete freedom of the band parameters. Furthermore, we test the performance of the MGM by fitting reflectance (I/F) and spectra ratioed to a common dusty terrain. The ratio approach can minimize error caused by calibration and atmospheric removal uncertainties. The goal is to investigate in greater detail the nature of compositional variations in pyroxene-bearing rocks.

Approach: Spectra were collected from OMEGA orbit 0232_2, highlighting the northeastern region of Syrtis Major and a geologic contact between the old (Noachian) cratered terrain and younger (Hesperian) volcanic deposits [10] (See [11] for a more detailed location map). Spectral parameter maps [12, 13] were used to highlight the pyroxene-rich regions and spectra were selected from spatially and compositionally diverse regions. Each spectrum of interest was also ratioed to a spectrum of a spectrally neutral, dusty terrain to try to remove surface and calibration affects. The same dusty region spectrum was used to ratio each spectrum.

MGM fits were determined for all spectra using the minimum number of absorption bands necessary to explain the original spectrum. The centers, widths, and strengths of the final fits were compared between ratioed and unratioed spectra to assess this approach with the MGM. Comparison between geologic units was also conducted to determine compositional variations.

Results: Final MGM fits for all spectra use an LCP and HCP absorption feature in the 1 and 2 µm regions. For spectra with greater LCP band strengths, the mean band centers of the LCP component occur near 0.89 and 1.85 µm, the HCP component near 1.03 and 2.24 µm. For spectra with greater HCP band strengths, the mean band positions of the LCP component occur near 0.86 and 1.86 µm and the HCP component near 1.05 and 2.3 µm. These data reflect the 1 and 2 µm band shift to longer wavelengths with increasing calcium.

It is significant that these band positions remain largely unchanged in their corresponding ratioed fits. Band center variations are often less than 0.01 µm in the 1 µm region and not greater than 0.03 µm in the 2 µm region; thus the performance of the MGM appears equivalent, but more analysis is needed.

It is also noteworthy that there is a strong correlation between relative pyroxene band strengths, and thus abundance, and geologic units. All spectra from the Noachian terrain have greater relative abundances of LCP, spectra from the Syrtis Major volcanics have greater abundances of HCP. This compositional variation indicates a fundamental change in composition of the crust from the Noachian to Hesperian.

Other compositional variations may be reflected in the shape of the 1.2 μm absorption feature, which is included in all the MGM fits for this study. Laboratory experiments suggest that this absorption is due to ferrous iron in the M1 crystallographic site [2,6]. The Hesperian aged volcanic spectra of Syrtis Major reveal an enhanced 1.2 μm band depth and width while maintaining the consistent performance of the 1 and 2 μm bands. Other analyses [11,14] indicate that olivine is the most likely mineral responsible for this enhanced 1.2 μm band. While not demonstrated yet by laboratory studies, this may be a technique to include olivine in the analyses to get a qualitative measure of olivine contributions with the MGM.

Discussion: Application of the MGM to remotely-sensed spectra can be a useful tool to estimate pyroxene compositions and relative abundances. These results indicate a distinct compositional difference between the LCP-rich Noachian terrains and Hesperian volcanics in northeastern Syrtis Major. Further study of spectra accompanied by MGM analysis will focus on the Hesperian volcanics around the central patera in order to more fully understand the mafic mineralogy.

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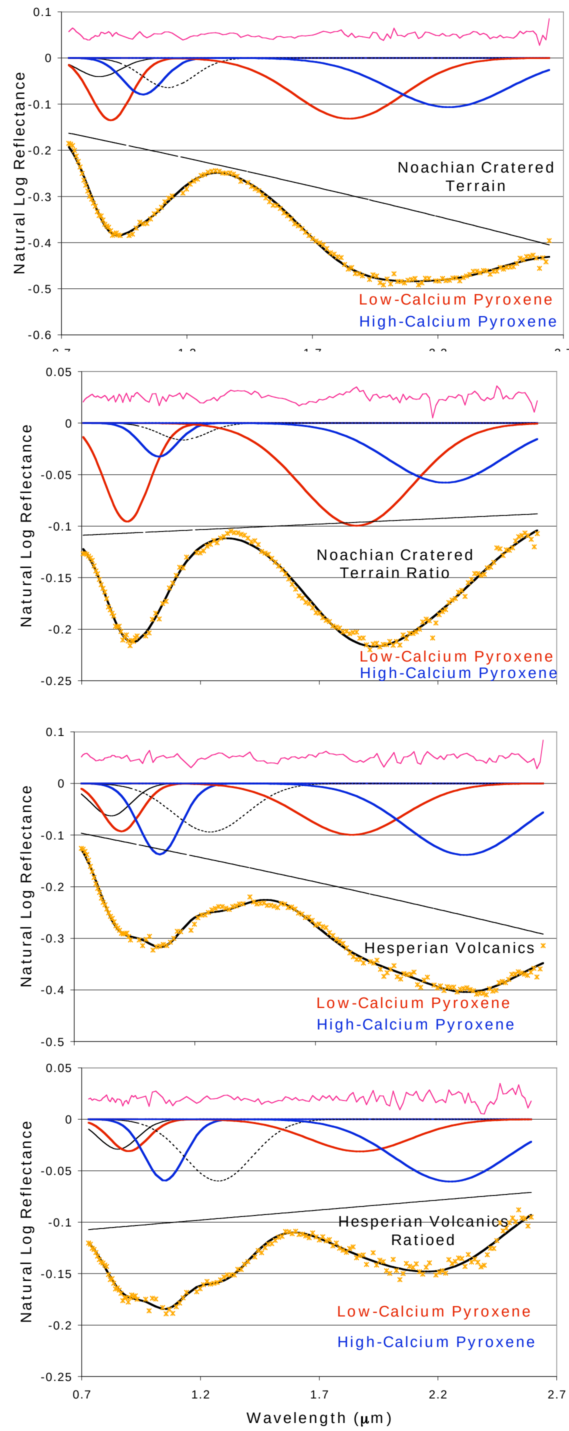

Fig. 1: Representative MGM fits for an LCP-rich region in the Noachian cratered terrain, an HCP-rich region in the Syrtis volcanic province, and their corresponding ratio spectra. The 1.2 absorption feature is represented by a dotted line.